SOUTHERN INSECT MANAGEMENT LABORATORY

USDA/ARS

Stoneville, Mississippi

Annual Report on Progress (CY 1994)

and

Plans (CY 1995)

CONTENTS

I. INTRODUCTION:

This report summarizes progress made on various research objectives in 1994 and presents plans for 1995.

Many of the results are preliminary and others are being released through established channels. Therefore, this report is not intended for publication and should not be referred to in literature citations.

The intent of this report is to give the reader an overview of Southern Insect Management Laboratory (SIML) research activities. These activities (progress and plans) address the laboratory and unit missions (listed on pages 4-7). To accomplish the mission, the Laboratory is divided into one unit at Stoneville [Southern Insect Management Research Unit (SIMRU)] and one unit at Mississippi State [Insect Rearing Research Unit (IRRU)] which is housed in the R. T. Gast Rearing Laboratory.

SIML activities are centered around seven research thrusts, which reflect present CRIS work units. These are:

1. Biological and genetic control and area-wide management of crop insect pests, emphasizing *Heliothis/Helicoverpa*;

2. Population ecology of insect pests for integrated control/ management systems;

3. Biology, ecology, behavior, and biological control of plant bugs, cotton aphids, and sweetpotato whitefly.

4. Strategies for managing crop insects, emphasizing the cotton agroecosystem and pesticide effectiveness;

5. Integrated control of pecan pests;

6. Host plant resistance in soybean pests; and

7. Mass propagation technology for the boll weevil, *Heliothis/ Helicoverpa* and their parasites, and beet armyworm.

The first through sixth areas are researched by the SIMRU and the seventh by the IRRU.

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This report is divided into four sections:

1. Report on research progress in CY 1994;

2. List of publications including those in press and accepted for publication.

3. Other indicators of progress such as presentations and papers in manuscript; and

4. Plans for CY 1995.

In each section, items are arranged by researcher (in alphabetical order of lead scientist; the name of lead scientist and cooperating and/or collaborating researchers are provided for each item). If the reader has questions pertaining to the item, he/she should contact the individual scientist or laboratory director.

II. MISSION STATEMENTS AND STAFF:

SOUTHERN INSECT MANAGEMENT LABORATORY
ARS/USDA, Mid South Area
P. O. Box 346
Stoneville, Mississippi 38776
Telephone: Comm: 601-686-5231
FTS: 700-497-2231
FAX: 601-686-5421

OFFICE OF LABORATORY DIRECTOR

MISSION:

The mission of the Southern Insect Management Laboratory is to conduct fundamental research on the biology, ecology, and rearing of field crop and pecan insect pests and their natural enemies; develop innovative biological, genetic, cultural, and chemical methods for suppressing insect pests; and integrate this knowledge into insect management systems, with emphasis on area-wide methods for *Heliothis/Helicoverpa*. A goal of this laboratory is to develop new and improved insect pest suppression strategies, including improvements in pesticide effectiveness, for population management approaches to improve crop production efficiency. Exotic organisms are received and cleared through the Stoneville Research Quarantine Facility for biological control of insects and weeds. Exotic predators and parasites are released and evaluated for establishment on field crop insect pests.

ARS PERSONNEL:

D. D. Hardee, Laboratory Director
T. G. Burton, Secretary AO
L. E. Taylor, Office Automation Assistant
W. W. Bryan, Quarantine Officer
G. G. Hartley, Entomologist (Insect Rearing)
H. E. Winters, Biological Technician (Insect Rearing)
R. L. Ford, Insect Production Worker
G. J. Patterson, Insect Production Worker
J. D. Warren, Engineering Technician (Shop)

SOUTHERN INSECT MANAGEMENT RESEARCH UNIT

MISSION:

To develop new knowledge on the biology of field crop insects for development of new and improved control tactics and to establish fundamental principles for encouraging and using natural enemies more effectively. To develop and integrate insect suppression strategies into field crop and pecan systems that minimize the cost of plant protection, yet are ecologically acceptable. Specifically:

1. Elucidate the efficacy of indigenous predators and parasites, particularly those attacking the bollworm, *Helicoverpa zea*, and tobacco budworm, *Heliothis virescens*.

2. Research and develop methods for augmenting parasite populations in management of insect pests of field crops, particularly use of *Microplitis croceipes* and other parasitoids for control of *Heliothis/Helicoverpa*.

3. Develop new knowledge on biology and behavior of *Heliothis/Helicoverpa* spp., initially emphasizing genetic characterization of *Helicoverpa* for establishment of a bollworm sterile hybrid and utilization of the *Heliothis* sterile hybrid and entomopathogenic viruses in area-wide management.

4. Conduct basic biological and ecological research on plant bugs, particularly the tarnished plant bug, *Lygus lineolaris*, aphids, the cotton aphid, *Aphis gossypii*, and the sweetpotato whitefly, *Bemesia tabaci*.

5. Develop monitoring and predictive technology through quantitative population ecology for field crop insect pests, particularly bollworm/budworm, tarnished plant bug, and cotton aphid.

6. Assess the role of early season host plants in the buildup of *Heliothis/Helicoverpa* and tarnished plant bug populations and devise new and innovative tactics for suppressing these populations.

7. Develop chemical/biorational control tactics for use in integrated systems.

8. Develop chemical, biological, and other nonchemical methods for control of insect and mite pests of pecans. Evaluate selections and native pecans for yield and adaptability to the mid-south.

9. Locate, develop, and evaluate soybean cultivars resistant to insects.

ARS PERSONNEL:

D. D. Hardee, Research Leader, Laboratory Director
(Supervisory Research Entomologist)

M. R. Bell, Research Entomologist
R. W. Hoagland, Biological Science Technician

G. W. Elzen, Research Entomologist
L. C. Adams, Biological Science Technician

D. E. Hendricks, Research Entomologist
D. W. Hubbard, Biological Science Technician

L. Lambert, Research Entomologist
W. L. Solomon, Biological Science Technician

M. L. Laster, Research Entomologist
S. B. Ginn, Biological Science Laboratory Technician

W. P. Scott, Research Entomologist
D. A. Adams, Biological Science Technician

M. T. Smith, Research Entomologist
M. C. Russell, Biological Science Technician

G. L. Snodgrass, Research Entomologist
R. A. Drake, Biological Science Technician

P. G. Tillman, Research Entomologist
F. M. Williams, Biological Science Technician

A. A. Weathersbee, Research Entomologist/Research Associate

INSECT REARING RESEARCH UNIT

MISSION:

The goal of this management unit, located at Mississippi State, Mississippi is to develop science and technology of mass propagation, storage, transfer, and release of cotton insects emphasizing the boll weevil and *Heliothis, Helicoverpa*, and their parasitoids, especially *Microplitis croceipes* (Cresson). Specifically:

1. Research is directed toward establishment of a cost effective propagation program capable of producing the quantity and quality of insects required to support field evaluation needs.

2. Initial research emphasis is placed on boll weevil production, automation of *Heliothis/Helicoverpa*, beet armyworm, and parasite rearing, establishment of quality control standards, establishment of standards for shipping and releasing insects, and evaluation of new rearing methods.

ARS PERSONNEL:

D. D. Hardee, Research Leader/Laboratory Director
(Supervisory Research Entomologist)

J. L. Roberson, Supervisory Entomologist
T. L. Blair, Insect Production Worker
E. M. Griffin, Biological Technician
D. K. Harsh, Engineering Technician
G. G. McCain, Secretary
R. E. Myers, Biological Laboratory Technician
C. Tate, Insect Production Worker
Vacancy, Insect Production Worker

III. SUMMARY OF RESEARCH PROGRESS FOR CALENDAR YEAR 1994:

A. *NARRATIVE:*

1. In-House

The methodology to produce large quantities of a viral microbial insecticide in vivo was developed. Using this technology, a total of ca. 8,488,000 cotton bollworm larvae were infected with a naturally-occurring entomopathogenic virus and the resulting dead larvae processed to produce enough of the virus to treat 215,000 acres, or a 20-mile diameter circle. After production was completed, the virus was formulated into a homogeneous batch, standardized through bioassay techniques, and labeled per EPA regulations for application on early-season weed hosts of the tobacco budworm and cotton bollworm. Using spray aircraft equipped with satellite guidance systems, 195,000 acres of the test area were treated with the virus preparation between 28 April and 3 May 1994 to investigate the use of this technique in large area pest management of these cotton insect pests. Although not all of the data are analyzed, results of the test were positive in that there were 53% less tobacco budworm and cotton bollworm moths captured in the test area compared to the average of 3 similar untreated areas within the Delta, with reductions ranging from 17% to 91% on daily trap captures. When insect cages were placed over virus-treated areas of weeds, the numbers of budworm and bollworm moths emerging was 59% and 64%, respectively. When random collections of larvae feeding on the early season hosts were made, 85% died from the virus. Additional results of this study will be forthcoming. **(M. R. Bell)**

Tests were conducted in the laboratory to examine new methods of producing entomopathogenic viruses for field application. The efficacy of producing the baculovirus from the beet armyworm was demonstrated, although additional information is needed prior to developing large scale methodology. **(M. R. Bell)**

The Stoneville Research Quarantine Facility (SRQF) received shipments from Nigeria and Cameroon, in support of *Callosobruchus subinnotatus* and *C. maculatus* research in

Mississippi and Alabama. The research is with pathogenic microorganisms of *C. maculatus* in Alabama and pheromone research of *C. subinnotatus* in Mississippi. Crossing trials with *Helicoverpa zea* and *H. armigera* from Beijing were completed. The crossings are a part of the *H. zea* sterile hybrid research project that is on-going in the facility. *Bemisia tabaci* rearing and research continued in the SRQF. Fecundity and longevity studies were conducted on two strains of the *B. tabaci* parasitoid, *Encarsia formosa*, using hibiscus as the host plant. **(W. W. Bryan)**

Greenhouse studies were completed on the burrowing activities of *M. croceipes* parasitized and non-parasitized *H. zea* larvae. The test was conducted with three soil types: delta sandy loam, coastal plain sandy loam, and coastal plain loamy sand. The test was conducted by placing the three soil types in 8" plastic greenhouse pots. Twenty pots of each soil type were planted with cotton (DES 119). The test used 60 parasitized and 60 unparasitized third instar H. zea. The treatments were: 1) one parasitized H. zea larva placed in a pot that did not contain a cotton plant; 2) one unparasitized H. zea larva was placed in a pot that did not contain a cotton plant; 3) one parasitized H. zea larva placed on a cotton plant (DES 119); and 4) one unparasitized H. zea larva placed on a cotton plant (DES 119). These treatments were replicated 10 times for each soil type. A clear plastic 30 ml diet cup was placed over the parasitized larvae and a small amount of diet was provided as a food source. When larvae were placed on plants, they were allowed to feed and drop from the plant naturally to burrow into the soils. A wire mesh chimney cage was placed over the plant once the larvae had been introduced. The parasitoid cocoons and host pupae were dug up, and the exact location in the soil was measured and recorded. The test required 120 pots of soil. The experimental design was a randomized complete block with a treatment factorial structure of [plants (2) X soil (3) X parasitized (2)= 12 treatments]. The manuscript and results are in preparation. **(W. W. Bryan)**

A M. croceipes rearing enhancement study was started in the SRQF to evaluate three oviposition methods (treatments). The three methods used were: 1) large cage with multicellular tray; 2) large cage with 32 cell trays; and 3) a modified tray/cage method. Three different density levels of *H. zea* larvae were used for each Treatment. The density levels were: 100, 200, and 300, 4 to 5 day old *H. zea* larvae. The test was replicated 3 times. A split plot, replicated in time, experimental design was used. Evaluation has not been completed. **(W. W. Bryan)**

Analysis of leaf chemistry of each Juglandaceae species and pecan cultivar was continued. **(O. T. Chortyk, M. T. Smith)**

In 1994, resistance to pyrethroids remained stable and at high levels in the tobacco budworm; resistance to organophosphates was lower than in 1993; resistance to carbamates was intermediate to the OP's and carbamates; and no increased tolerance was found to *Bacillus thuringiensis* based products. **(G. W. Elzen)**

Current resistance management strategies for tobacco budworm/ bollworm should be maintained in view of these recent findings and especially because pyrethroid resistance was greater in tobacco budworm collected from wild hosts in May 1994 than from budworms collected in August 1993 or in cotton in 1994. **(G. W. Elzen)**

Two large replicated field trials with the IGR fenoxycarb gave little conclusive evidence for population regulation effects; however, the ability to evaluate the IGR was hampered by low budworm/bollworm infestation pressure throughout 1994. **(G. W. Elzen)**

Bioassays showed that diflubenzuron was more effective in life cycle disruption and mortality effects on beet armyworms than fenoxycarb or B.t. alone. **(G. W. Elzen)**

Strains of tobacco budworm collected in Mississippi were evaluated in bioassays to four classes of insecticides. No cross-resistance between different classes of insecticides with the exception of carbamates and organophosphates was found. Since organophosphates and carbamates have the same target, cross-resistance between them is further evidence for target-site resistance as the primary resistance mechanism. The data indicated that multiple resistance may be more wide-spread than previously reported. **(G. W. Elzen)**

A lack of correlation between male tobacco budworm resistance in moths caught in pheromone traps versus those caught free-ranging indicates that traps may underestimate the level of resistance in adults and larvae. **(G. W. Elzen)**

A second year of extensive evaluations of traps, lures, and killing strips for boll weevils showed that (1) the Consep trap (old Hardee trap) was equal or superior to the trap manufactured and used by the Southeastern Boll Weevil Eradication Foundation (SEBWEF) and the Hercon Scout® trap, (2) there was no difference between the

two lures being used in the Boll Weevil Eradication Program, and (3) a DDVP killing strip was again equal to the Hercon strip in killing boll weevils before they escaped from traps. It was noted that the Consep trap was superior to the other traps tested in that (1) considerably less time was required to check and service this trap, especially when trap numbers were high, and (2) killing strips were more effective (lasted longer) in the Consep trap than the Scout or the SEBWEF traps. **(D. D. Hardee)**

Comparisons of plots of Bt transgenic cotton (Monsanto Line 757), MD51 (nectariless smoothleaf), and grower-planted varieties (Sure-Grow 501 or DES 119) indicated no differences in any insect numbers except (1) numbers of cotton bollworm/tobacco budworm larvae were less in Bt cotton and (2) numbers of tarnished plant bug nymphs and adults were greater in Bt cotton. Numbers of tarnished plant bugs were 31% more in Bt cotton than in DES 119 and Sure-Grow 501 and 54% more in Bt cotton than in MD51. **(D. D. Hardee)**

Production of insects for USDA-ARS research by the Stoneville Insect Rearing Unit required maintenance of eleven insect species: *Heliothis virescens, Helicoverpa zea, Heliothis virescens* sterile hybrid, *Anticarsia gemmatalis, Pseudoplusia includens, Spodoptera exigua, Galleria mellonella, Microplitis croceipes, Cardiochiles nigriceps, Microplitis demolitor,* and *Cotesia kazak*. Support of USDA-ARS scientists at Stoneville and laboratories in Tifton, GA; Mississippi State, MS; College Station, TX; and Weslaco, TX required production of 312,000 *H. virescens* pupae, 308,000 *H. zea* pupae, 53,000 *H. virescens* sterile hybrid BC pupae, 274,000 *P. includens* pupae, 206,000 *A. gemmatalis* pupae, 219,000 *S. exigua* ppae, 85,600 *C. nigriceps* cocoons, 81,000 *M. croceipes* cocoons, 19,000 *M. demolitor* cocoons, 81,000 *C. kazak* cocoons, 54,488,000 *H. virescens* eggs, 44,446,000 *H. zea* eggs, 3,220,000 *H. virescens* sterile BC eggs, 23,358,000 *P. includens* eggs, 18,420,000 *A. gemmatalis* eggs, 21,302,000 *S. exigua* eggs, and 26,000 *G. mellonella* larvae. Additional research support included mixing, dispensing, and filling 160,100 30 ml plastic cups and 1,012 3.8-liter multicellular trays with artificial diet. Total diet mixed and dispensed inn 1994 was 18,118 liters. Also, several short courses in insect rearing techniques were given to employees of: Valent USA, Greenville, MS; Ciba Research Station, Winterville, MS; Zeneca Ag Products, Leland, MS; Stoneville Pedgreed Seed Co., Stoneville, MS; Sandoz Corp., Palo Alto, CA; and The Institute of Plant Protection, People's Republic of China. **(G. G. Hartley)**

Progress was made in developing a disposable multicellular larval rearing container that is compatible with Stoneville rearing techniques. A disposable polystyrene tray used for growing seedlings was used to successfully rear larvae of the tobacco budworm. The tray measures 30 cm x 50 cm x 3.1 cm and contains 400 1.5 cm diameter cells. The complete unit including tray and cells cost about $1.00. Additional work will be conducted with Oliver Co. to develop a disposable lidding to replace the porex lid in use at present. **(G. G. Hartley)**

Approximately 150 researchers located in 37 states, England, Canada, and Japan participated in the Cotton Foundation and American Soybean Association Insect Distribution Program. Prices for insects increased in 1994. Pupae are now $35.00 per 100 and eggs are $25.00 per 1,000. The American Soybean Association now requires advance payment before insects can be shipped through their program. We do not anticipate the need for a price increase during 1995. Funds provided by these programs are used to defray insect rearing expenses of the SIML. **(G. G. Hartley)**

A pheromone chemical, (Z)-11-hexadecenal (Z11-HDAL), deployed in a 45 A. cotton field as 6 treatments, 12 days apart at the rate of 2 gram/A (0.4 ha), significantly disrupted the mating behavior of male tobacco budworm and bollworm moths as indicated by decreased captures of these male insects in traps baited with pheromone (virelure). These catches were compared with captures in traps set near an untreated 45-A cotton field. Significant reduction in trap captures in the treated plot indicated that mating behavior of male and female moths among the treated cotton was also disrupted and reproduction was reduced. During this period, catches of tobacco budworm and bollworm males in traps baited with pheromone were compared with catches in traps installed in an untreated (CK) plot (40 A) of cotton. The two test plots were nearly adjacent and were on the same farm. Tobacco budworm and bollworm infestations (larvae and eggs) in the treated plot ranged from 1% (at low moth densities) to 7% (at high moth density levels) when infestation levels in the untreated plot ranged from 1% to 12%, respectively. Insecticide was applied to the treated plot only 2 times during the cotton-growing season once in June, for weevils and thrips, and again in August for beet armyworms. The untreated check plot was treated with insecticides 4 times during the season, for weevils and thrips, twice for bollworms and tobacco budworms, and once for beet armyworms. The field treated with pheromone gave a cotton yield of 1 3/8 bale/A, 1/8 of a bale/A greater than the untreated field, which gave 1 1/4 bale/A. **(D. E. Hendricks)**

A survey of the abundance of beet armyworm moths (BAW), *Spodoptera exigua*, was conducted in the Mississippi delta region from April to November 1994. A trapline composed of 54 bucket type Unitraps was installed in a north-to-south line from near Skene, Miss. in southern Bolivar Co. to Onward in Sharkey Co. These traps were set about 1.3 miles apart and baited at 3-week intervals with rubber septa impregnated with synthetic beet armyworm sex pheromone. Trapping of male beet armyworm moths started on April 7 and continued throughout the growing season. Traps were checked, and moths were counted and tallied twice each week. BAW moths were first caught on April 10, three nights after the traps were baited. These moths were captured in 5 traps set at the north end of the trapline. Average number captured during the first week of the survey, April 7-13, ranged from 0.13 to 0.05/trap/night. Highest average number/trap/night caught in April was 1.6 BAW moths on April 28. In May a broad peak occurred between May 3-11, and the highest number of BAW caught during this period was 2.03/trap/night on 9 May. In June, there was another single, prolonged period of BAW captures from June 8-14, and within this span catches peaked at 1.22 moths on June 10. Wings on the majority of moths caught from April 7 to June 30 were covered with nearly a full complement of scales. Color and design of the scales were clear and characteristic of the BAW, and density of scales on the wings indicated that these moths did not fly great distances before they were captured. Hence, BAW moths captured during this period were considered either adults or progeny of BAW that had overwintered in the lower Mississippi River delta region in Bolivar and Washington counties. From July 1 to November there were four distinct peaks in captures of BAW. These peaks occurred in intervals of about 26-30 days. Numbers of BAW caught/trap/night from July 1 to November 20, at successive peaks were 15.8 (July 15), 96.4 (August 2), 282.8 (September 2), and 399.8 (October 3), respectively. **(D. E. Hendricks)**

An automatic electronic moth detector system used with inverted pheromone traps has been commercialized by Automata, Inc., Grass Valley, Calif. Invention of this system was made by Don E. Hendricks, USDA-ARS. Computer software required to report and collate moths detected has been translated from Commodore Basic to MicroSoft's Qbasic, GWbasic, or Basica in April 1994. The remote moth detection system has been used for five years for the detection of tobacco budworm and bollworm moths inhabiting cultivated field crops. The automatic moth detection system was used in Washington Co., Miss. to detect fluctuations in numbers of budworm and bollworm moths throughout the 1993 and 1994

growing season. Data collected from the automatic system were compared with numbers of moths captured daily in traps installed near cotton fields up to 10 miles away. Automatic moth detection systems used to count moths near cultivated corn and cotton by agricultural consultants near Lubbock, Texas were baited with appropriate pheromone and interfaced with the data-logger of a portable monitoring station. Moth detection data and weather data were reported upon request by "keying" a cellular telephone installed at the site of the remote weather station. Surveys of bollworm and tobacco budworm moth populations using replicated installations of 30-in. diam. pheromone traps baited with appropriate pheromone baits showed that moth catches from clusters of 3 to 4 traps set 50 ft apart at 3 different field locations represented true population fluctuations. Significant oviposition on cotton preceded by 3 days the sharp increase in moth captures in traps at the beginning of each moth flight during the season. **(D. E. Hendricks)**

Population density profiles plotted for the cotton crop season showed a later and significantly smaller build-up of tobacco budworms on cotton in 1994 than in 1993. Wild geranium and crimson clover supported the first 2 generations of beet armyworms, tobacco budworms, and bollworms. Velvetleaf supported the 2nd to the 5th generations of budworms. Corn, soybeans, and smartweed supported the 2nd to the 5th generations of bollworms. In 1994, development of cotton preceded the onset of major peaks of bollworms, budworms, and beet armyworms by about 2 weeks compared with the development of cotton and insects in 1993. In 1994 most cotton escaped serious infestations of beet armyworms because of this early season cotton development. Correlation of weather conditions with population profiles during the growing season indicated that the ice storm of Feb. 9-13 had little effect on development of the major cotton insect pests. **(D. E. Hendricks)**

Evaluation of twelve insect resistant soybean genotypes with different maturity dates to determine if resistance levels change during plant maturation was completed. The studies were conducted in a large field cage utilizing laboratory reared insects. All genotypes have essentially the same level of resistance prior to fruiting. After the onset of fruiting the later maturing genotypes appear to have a higher level of resistance than earlier maturing genotypes. Additional studies will be required to determine if resistance levels decrease during the fruiting phase or if later maturing genotypes develop higher levels of resistance. **(L. Lambert, E. G. Hartwig, T. C. Kilen)**

Evaluations with soybean looper and velvetbean caterpillar were continued to evaluate the USDA-ARS soybean germplasm collection for resistance to insects. In field cage evaluations of 900 accessions several genotypes were identified with high levels of resistance to foliar feeding by soybean looper. The resistant accessions will be further evaluated and used in a breeding effort to develop soybean cultivars with high levels of resistance to insects. **(L. Lambert, T. C. Kilen)**

Studies were initiated with soybean isolines with normal, dense and glabrous pubescence types to determine the influence of pubescence on the effectiveness of parasitoids. The presence or absence of pubescence did not impact the level of parasitization. **(L. Lambert, P. G. Tillman, J. E. Mulrooney)**

Studies were initiated with soybean to determine the influence of irrigation of soybean on the development of soybean looper populations and the subsequent impact on yield. Due to heavy rains during critical periods and the failure of insects to survive, no data were obtained. **(L. Lambert, L. G. Heatherly)**

A pilot test to suppress the wild tobacco budworm, *Heliothis virescens* (F.), population by rearing and releasing insects with a sterile male trait was conducted during 1991-1994. Backcross moths were released in a 10 mile square area in Washington and Sunflower Counties, Mississippi in 1992 and in Bolivar County in 1993. Pheromone traps were used to monitor insect populations in both areas during both years and the non-release area served as the control. Moth releases were directed at the overwintered tobacco budworm emergence and were placed in the field 2 April to 15 May in 1992 and 12 April to 25 May in 1993. Approximately 69,000 moths per day were released in 1992 and 70,000 per day in 1993. A 3.0:1.0 released:wild ratio was achieved in 1992. This ratio dropped to 1.3:1.0 and 1.0:2.3 during June and July, respectively, due to moth movement into and out of the release area. Continued monitoring of this area in 1993 showed a 1.0:2.2 backcross:wild ratio (29.9% sterility) carried over the winter. This ratio dropped to 1.0:5.2 backcross:wild in June, increased to 1.0:4.7 and 1.0:3.4 during July and August, respectively. A 2.6:1.0 released:wild ratio was achieved for the Bolivar County release in 1993. This ratio declind to 1.0:1.6 in June, 1.0:3.6 in July and 1.0:4.0 in August. Continued monitoring in 1994 showed that male sterility in the overwintered populations across both release areas was 12.1%. **(M. L. Laster)**

Helicoverpa armigera (the Old World bollworm) was imported into the quarantine research facility at Stoneville, MS and crossed with *H. zea* (the American bollworm) in search of hybrid sterility. Reciprocal backcrosses through four generations and inbred crosses through two generations were studied to determine mating incidence and fertility. All crosses mated and produced fertile offspring and no sterility was detected. **(M. L. Laster)**

The Insect Rearing Research Unit (IRRU) maintained colonies of *Anthonomus grandis grandis*, *Heliothis virescens, Helicoverpa zea, Microplitis croceipes,* and *Catolaccus grandis*. Approximately 1.8 million boll weevils were shipped to Cotton Foundation recipients, in addition, tray components and special diet formulations were prepared and shipped to off-site locations for research purposes. Mass-rearing research and production programs wee conducted in support of a *Helicoverpa zea* rearing project to propagate eight million larvae to serve as a living host for production of a baculovirus used in a field assessment test. The project met production output and delivery timetables. *Anthonomus grandis grandis* larvae were reared and shipped to ARS/APHIS project in south Texas to propagate and evaluate field performance of *Catolaccus grandis* parasites. Major research efforts were directed to screening improved rearing techniques for laboratory production of *Microplitis croceipes*. The improved rearing techniques have stabilized production of the maintenance colony. **(J. L. Roberson)**

The *Helicoverpa zea* rearing program was completed on schedule providing adequate quantities of larval host material at feasible cost levels. The ability to produce the quantity and quality of host material at marginal labor cost enhance the development for commercial production of virus if the technology proves effective as a field insecticide. Equipments designed and constructed to encapsulate boll weevil larvae in parafilm sheeting were shipped to Weslaco, Texas for use with the on-going *Catolaccus grandis* rearing program. The development and construction of these equipments were necessary to enable production scale-up and field assessment. Rearing procedures for *Microplitis croceipes* enable separation of host and selection of individuals for maintaining colony stock. The selection process serves to continually upgrade laying stock quality. The procedures are currently operating as planned. **(J. L. Roberson)**

A large field study was conducted to compare tarnished plant bug populations in nectaried and nectariless cottons. Methods of sampling that are recommended in the Insect Control Guide for the

tarnished plant bug were evaluated in both DPL 20 (nectaried) and MD-51 (nectariless). Plant bug populations were low throughout the season in the test field. When yield data were taken, more cotton was harvested in plots that received an automatic treatment than in plots that reached threshold within any sampling method. **(W. P. Scott, G. L. Snodgrass)**

A three year study was completed in 1994 that compared deltamethrin (Decis) to Karate and Baythroid for bollworm control in large field plots. Under moderate bollworm/tobacco budworm pressure in 1994, there were no differences in level of control or yield with Decis, Baythroid, and Karate applied at 0.02, 0.033, and 0.033 lbs AI/acre. Studies over the 3-year period indicate that Decis was as effective as Karate and Baythroid in controlling bollworm/tobacco budworm even when applied at a lower use rate per acre. **(W. P. Scott)**

Small plot and spray table studies were conducted with Fipronil (Rhone Poulenc) on plant bugs and boll weevils. Spray table studies indicated that a gel formulation of Fipronil was less effective than a WG formulation applied at the same rate on plant bugs and boll weevils. In small plots Fipronil and Admire were more effective in controlling high plant bug populations than Vydate. **(W. P. Scott)**

The pecan aphid complex is composed of three aphid species: the blackmargined aphid, *Monellia caryella* (Fitch), the yellow pecan aphid, *Monelliopsis pecanis* Bissell, and the black pecan aphid, *Melanocallis caryaefoliae* (Davis). Investigations of host plant resistance, host plant specificity and host plant selection of these three aphid species are being conducted at several plant phylogenetic levels. **(M. T. Smith)**

Analysis of biological and behavioral performance data on all three aphid species on each Juglandaceae species and pecan cultivar is in progress. **(M. T. Smith)**

The surface and internal morphology of each Juglandaceae species and pecan cultivar are being investigated as a function of plant phenology (over a given growing season) via SEM and light microscopy. All leaf tissue samples collected in 1993 were mounted onto SEM stubs and then coated during 1994. Leaf tissues are currently in storage awaiting examination and analysis. **(M. T. Smith, Rex Paul)**

As part of these studies, investigations were performed during 1994 with the objective of developing artificial diet methodology that would be utilized in bioassaying phytochemical components of non-preferred and/or unsuitable host plants. Progress was made with respect to the formulation of a suitable liquid diet, as well as the development of a workable feeding apparatus. However, additional research is needed with respect to the development of an acceptable surface through which the aphids will feed. **(M. T. Smith)**

Preliminary investigations were conducted during 1994 on the analysis of pecan aphid biological and behavioral performance on grafted plants of each of the Juglandaceae species and pecan cultivars. Methodology developed from these studies will be utilized in the subsequent investigations in 1995. **(M. T. Smith)**

The second year of a research project was conducted to determine the utility of a trap cropping system designed to intercept migrating stinkbug species as they move from soybean to pecan. Results from the 1993 tests showed that: (1) the percent of pecans damaged by stinkbugs decreased significantly with increasing distance into the pecan orchard from the soybean field; (2) sweep net sampling for stinkbug density in pecan trees is inefficient; (3) cultural characteristics of purple hull pea (cowpea) are less desirable than hill pea due to the short window of time during which it is attractive to stinkbugs. Hill pea provided an attractive trap crop for the migrating stinkbugs for a longer period of time than did the purple hull pea. However, field pea is not commercially available. **(M. T. Smith)**

In the 1994 season, speckled pea (which is commercially available and has the same desirable cultural characteristics as hill pea), was planted in a continuous strip along the edge of a pecan orchard which borders a soybean field. Only half of the border was planted to peas (treated plot), while the other half remained fallow (check plot). Population density of several stinkbug species was monitored in the soybeans and peas using sweep net and drop cloth methods. Control of stinkbugs within the peas was investigated. To date, the drop cloth method appears to be the more appropriate sampling method. However, both sampling methods appear to underestimate stinkbug population levels in both the soybeans and peas. Finally, nut harvest yielded little or no useful measure of trap crop efficiency due to the lack of nuts available at harvest. This resulted from the extremely large numbers of birds which migrated into the orchard approximately 2-3 weeks prior to harvest and removed what would

have otherwise been an adequate crop for evaluation of stinkbug damage. This occurred in a number of orchards in the Delta, likely as a result of the small mass crops available in the wild following the 1994 ice storm. Therefore, this experiment will be repeated in 1995 using the cultural, and stinkbug sampling and control information obtained in the 1994 study. **(M. T. Smith, G. L. Snodgrass, T. Jenkins, B. Horton, M. Hughs)**

Research was continued on the re-evaluation of the pheromone of the hickory shuckworm, *Cydia caryana*. However, several questions regarding the pheromone were investigated. Results from the 1993 field studies provided evidence suggesting increased attractancy of the commercial lure by the addition of one of the two new compounds isolated in 1992. The 1994 field studies are still in progress at the time of this report. However, there is clear evidence that one of the new formulations is significantly more attractive than the commercial lure. A new experimental procedure was also investigated during these studies and appears to be very promising. **[M. T. Smith, G. Gries (Simon Fraser University), Carroll Yonce (USDA-ARS), Salvador Galindo (pecan grower)]**

Results from the 1993 field studies indicated that the hickory shuckworm is not uniformly distributed within a pecan orchard. Therefore, more definitive investigations were performed in 1994 with respect to the spatial distribution of the hickory shuckworm moth within pecan orchards as determined by pheromone trap catch. Data collection is still in progress at the time of this report. This new information will ultimately be used to determine the appropriate number of pheromone traps per unit area that a grower needs in order to obtain a reliable estimate of moth presence and density. **[M. T. Smith, Carroll Yonce (USDA-ARS), Salvador Galindo (pecan grower), Jeff White & Steve Whitesides (Ecogen)]**

Research was continued for a second year on the collection, isolation, and chemical characterization of the pheromone of the pecan weevil, *Curculio caryae* (Horn). In 1993, volatile collections and EAD responsiveness were made of male weevil + host volatiles, female weevil + host volatiles, host volatiles alone, male weevil volatiles, and female weevil volatiles. EAD analysis of male or female volatiles alone indicated differential responsiveness to two specific GC peaks which were not apparent in the EAD analysis of volatile samples where host odors were present. This may be an indication of several biologically active volatiles unique to the weevils. **[M. T. Smith, G. Greis & H. Pierce (Simon Fraser University), Ruth Dearing (private grower in Holly Grove, AR), Fred Taylor (private grower in Como, MS)].**

The 3rd year of a study of factors (biotic and abiotic) governing the seasonal dynamics of *Aphis gossypii* was completed. Among the biotic factors monitored was the entomopathogenic fungus *N. fresenii*, a natural controlling agent of *A. gossypii*, and *Lysiphlebus testaceipes*. Abiotic factors monitored included leaf wetness and air temperature, each recorded at the three locations within the plant canopy. In addition, soil moisture and temperature, air temperature and relative humidity above the plant canopy, as well as rainfall were also monitored. Although data from these studies have not as yet been analyzed at the time of this report, it is clear that: (1) *L. testaceipes* may be the key natural controlling agent of the cotton aphid during the early season cotton aphid peak (mid to late July), and that this parasitoid is scarce during the second cotton aphid population peak in late-season; (2) *N. fresenii* is the key natural controlling agent of the cotton aphid during the late-season cotton aphid peak (mid to late August); (3) neither *L. testaceipes* nor *N. fresenii* are solely responsible for population declines of the cotton aphid in early- and late-season, respectively; (4) aphid density, leaf wetness and source of inoculum represent at least 3 key factors which govern epizootics of *N. fresenii* within the cotton aphid. **(M. T. Smith)**

Research was continued on the evaluation of two strains of *Encarsia formosa*, a parasitoid of the silverleaf whitefly (SLWF), *Bemisia argentifolia*. Investigations of both biological (age specific fecundity, developmental rate, percent parasitism and percent emergence) and behavioral performance were conducted under different environmental (temperature) regimes. This research is designed to identify those parasitoid species most appropriate for release and control of the SLWF in very select geographic areas and on high value cash crops in the United States where the SLWF is of major importance (Imperial Valley in California, Rio Grande Valley in Texas, and Florida). Results from these studies clearly show that temperature strongly influences parasitoid efficacy, and that the environmental conditions from which these exotic parasitoids originated match very closely the temperature in which their performance was optimal. These data strongly suggest the existence of two ecotypes of *E. formosa*. Current research has been initiated to develop methodology for the investigation of the effects of host plant on parasitoid efficacy. **(M. T. Smith, R. Hennessey)**

Insecticide treatments applied to cotton with a high clearance sprayer during July 1994 at Stoneville, MS, were ineffective in controlling tarnished plant bugs in the field. Reductions (as

compared with the untreated check) in plant bugs in the best treatments averaged 56.7% (adults) and 45.2% (nymphs) using dicrotophos and acephate, respectively. Laboratory tests with adults from the field using a glass vial bioassay, or cotton terminals treated with insecticides on a spray table, indicated that the control problems were caused by insecticide resistance and/or inadequate coverage of the plants in the field with insecticides. **(G. L. Snodgrass, G. W. Elzen)**

A pyrethroid resistant plant bug colony (originally collected in cotton in August 1993) was reared through 8 generations in the laboratory. Various tests were performed with the colony including studies on synergism and the inheritance of resistance. Resistance to permethrin declined from an LC_{50} of 138 µg/vial for the parent generation (using a glass vial bioassay) to an LC_{50} of 19.5 µg/vial in the F_7 generation. This colony was also tested in various generations in the laboratory for resistance to cypermethrin, fenvalerate, bifenthrin, endosulfan, acephate, dicrotophos, malathion, methyl parathion, and dimethoate, and LC_{50} values determined using a glass vial bioassay. For almost every insecticide, the pyrethroid resistant colony had significantly higher resistance as compared to a susceptible laboratory colony and/or susceptible plant bugs collected from weeds in a non-agricultural area near Crossett, AR. Tarnished plant bugs from 2 cotton fields at Stoneville, and from 1 field near Hampton, MS, collected in July and August were also found to be resistant to pyrethroids using the glass vial bioassay. **(G. L. Snodgrass)**

Resistance levels to acephate, dimethoate, dicrotophos, malathion, methyl parathion, endosulfan, oxamyl, permethrin, fenvalerate, bifenthrin, and cypermethrin were determined for 3 groups of adult plant bugs using a glass vial bioassay. The 3 groups were: a laboratory colony reared at Stoneville since 1989, bugs from the weeds *Erigeron annuus* and *E. philadelphicus* collected near Stoneville during April-June, and bugs from these same 2 species of weeds collected near Crossett, AR (an area where cotton is not grown and the plant bugs have little or no exposure to the cotton insecticides tested). The study required testing of over 10,000 adult bugs and established a basis for comparison of resistance levels in future studies. **(G. L. Snodgrass)**

Cotton fields located in 1600 square miles of the Delta were sampled weekly for bollworm and tobacco budworm eggs and larvae during June and July 1994. The fields were located in 4 areas (each ca. 400 square miles) of which 3 areas were checks. The

fourth area received an aerial application of an insect virus to all wild host plants in the area in April to kill first generation bollworm and tobacco budworm larvae found on them. Each of the 4 areas were divided into quadrants and the location of cotton fields in each quadrant recorded. Fields were sampled by whole plant examinations in young cotton. Sampling changed to visual searches of terminals and fruit and foliage in the upper half of each plant when the cotton began to square. Each field was sampled by 2 people and in each sample 10 plants were examined. Fields were classified as small, medium, or large and 20 samples (10 per observer) were taken in small fields while 40 samples (20 per observer) were taken in medium and large fields. All eggs and larvae found were taken back to the laboratory for rearing and species identification. In each check area, 5 fields were picked at random from each quadrant (20 total) each week and sampled. In the single treated area 6 fields (7 in one quadrant, 25 total) were picked at random each week from each quadrant and sampled. Data entry from this test was recently completed and checked for errors. This entailed entry of approximately 20,000 lines of data. Statistical analysis will be completed in November. **(G. L. Snodgrass, M. R. Bell, D. D. Hardee)**

Releases of normal-winged (flying) *M. croceipes* and clipped-winged (non-flying) *M. croceipes* mutants in geranium resulted in higher parasitization by the former individuals of this species. **(P. G. Tillman)**

M. croceipes females released in a large cage parasitized equal numbers of the beet armyworm on the densely pubescent and glabrous isolines of soybeans. **(P. G. Tillman)**

A native population of *Cotesia marginiventris* parasitized equal numbers of the beet armyworm on the densely pubescent and glabrous isolines of soybeans in small field plots. **(P. G. Tillman)**

Under the same field conditions, *C. nigriceps* parasitized more *H. virescens* larvae than *M. croceipes* in small field plots. **(P. G. Tillman)**

A new rearing method has been developed with Jon Roberson at the GAST facility in Mississippi State, Miss. This method produces healthy (virus-free) adult parasitoids at a reduced cost. These wasps can be taken directly to the field in the small (4x8") package in which they were reared. **(P. G. Tillman)**

When sprayed topically, nine insecticides, including endosulfan, chlorpyrifos, dicrotophos, dimethoate, methyl parathion, profenofos, bifenthrin, cyhalothrin and cyfluthrin, were extremely toxic to adult parasitoids of *M. croceipes* and *C. nigriceps*, causing 100% mortality. Treatment with thiodicarb resulted in low (44%) mortality for *M. croceipes* males and 0% mortality for *M. croceipes* females and *C. nigriceps* males and females. Mortality was also lower for *M. croceipes* males (92%) and *C. nigriceps* for both males (92%) and females (60%) when treated with oxamyl. Treatment with three other insecticides, acephate, azinphosmethyl and cypermethrin, resulted in lower mortality for *C. nigriceps*. Differential susceptibility to five insecticides, oxamyl, thiodicarb, acephate, azinphosmethyl and cypermethrin, occurred between the two wasp species. **(P. G. Tillman)**

Preliminary studies show that photoperiod is more critical than temperature in breaking diapause for *M. croceipes*. **(P. G. Tillman)**

A new efficient method for rearing *C. marginiventris* was developed. **(P. G. Tillman)**

A experiment which examined the interaction of aphicide treatments with DES 119 cotton and a smooth isoline was repeated to ascertain that results were similar to those obtained last year. Both cotton lines were monitored for cotton aphid, *Aphis gossypii* Glover, densities and effects on yield in aphicide-treated and untreated plots. Treated plots recieved dicrotophos applications to maintain the density of aphids below 30 per leaf. All plots were treated with oxamyl and/or methyl parathion for tarnished plant bug and boll weevil, and with thiodicarb for budworms and bollworms, at recommended rates as required to maintain these pests at equal low densities. The latter compounds minimally impacted cotton aphid populations. Numbers of cotton aphids differed significantly between aphicide-treated and untreated plots, regardless of the cotton line. Numbers of aphids in aphicide-treated plots did not differ between the smooth and hairy lines. In the untreated plots, numbers of aphids on the smooth cotton were significantly lower than on the hairy cotton. Yield estimates for the the smooth line with and without aphicide, and the hairy line with and without aphicide were 2775, 2820, 2578, and 2879 lbs. seed cotton/A, respectively. Only the latter two yield estimates differed significantly ($P \leq 0.05$). These data indicated that cotton aphids did not effect the yield of the smooth isoline of DES 119, and supported data from last year. In contrast to data obtained last year, a yield loss was observed with DES 119 (normal, hairy line) when it was treated with

aphicide, rather than untreated. Reasons for this anomaly are not yet apparent but the non-typical, excessive rainfall during July likely was instrumental in creating the results observed this year. Nevertheless, these data further substantiate our claim that there are high yielding, smooth cotton lines which need no chemical protection from aphids to assume maximum yield potential. **(A. A. Weathersbee III, D. D. Hardee, W. R. Meredith)**

An experiment was initiated to evaluate the yield impact of cotton aphid across a range of 12 cotton cultivars differing in leaf trichome density. A trend for lower aphid densities on cultivars with reduced leaf trichome densities was observed. The strength of this relationship will be analysed using regression procedures. Cotton yield will be similarly examined after drying and weighing of samples is completed. **(A. A. Weathersbee III, D. D. Hardee)**

Data were collected for the second year to facilitate the development of a regression equation useful in predicting the occurrence of epizootics in cotton aphids caused by the fungal entomopathogen, *N. fresenii*. These data will be combined with those from last year and analysed during the winter. The final objective is to create a tool useful in making field predictions of aphid population declines based upon density and composition of the population when samples are taken. **(A. A. Weathersbee III, D. D. Hardee)**

2. Extramural

None.

B. *INDICATORS OF PROGRESS:*

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Laster, M. L. *Proboscidea louisianica*: An unreported host of *Heliothis virescens* (Lepidoptera: Noctuidae). Submitted to J. Econ. Entomol.

Laster, M. L., and D. D. Hardee. Intermating compatibility between the North American *Helicoverpa zea* and *H. armigera* (Lepidoptera: Noctuidae) from the former Soviet Union. Submitted to J. Econ. Entomol.

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Scott, W. P., and D. A. Adams. Comparison of insect populations and yield in narrow row and normal row plantings of cotton. For J. Econ. Entomol. (In preparation).

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Smith, M. T., R. F. Severson, C. C. Reilly, and B. W. Wood. Host-plant selection by the blackmargined aphid (*Monellia caryella* Fitch), the yellow pecan aphid (*Monelliopsis pecanis* Bissell) and the black pecan aphid (*Melanocallis caryaefoliae* Davis), on the North American species of the Juglandaceae: A comparative study of foliar cuticular chemistry and host-plant recognition. For J. Chem. Ecol. (In preparation).

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Smith, M. T., R. F. Severson, and R. C. Gueldner. Seasonal dynamics of the surface chemistry of pecan leaves, rachis and nut. For J. Agric. Food Chem. (In preparation).

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Snodgrass, G. L. Pyrethroid resistance in a field population of the tarnished plant bug (Heteroptera: Miridae) in cotton in the Mississippi Delta. For J. Econ. Entomol.

Snodgrass, G. L. Distribution of the tarnished plant bug (Heteroptera: Miridae) within cotton plants. For Environ. Entomol.

Snodgrass, G. L. A glass vial bioassay for determining insecticide resistance in adult tarnished plant bugs (Heteroptera: Miridae). For J. Econ. Entomol.

Snodgrass, G. L., and G. W. Elzen. Insecticide resistance in a tarnished plant bug population in cotton in the Mississippi Delta. for Proc. Beltwide Cotton Prod. Res. Conf., 1995.

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Tillman, P. Glynn, Jon L. Roberson, and D. D. Hardee. 1994. Disposable cardboard box for rearing/release of *Microplitis croceipes*. Submitted to Southw. Entomol.

Tillman, P. G. Functional response of *Microplitis croceipes* and *Cardiochiles nigriceps* (Hymenoptera: Braconidae) to variation in *Heliothis virescens* (Lepidoptera: Noctuidae) density. For Environ. Entomol.

Tillman, P. G. Field parasitization of *Heliothis virescens* by the parasitoids, *Microplitis croceipes* and *Cardiochiles nigriceps*. For Southwest. Entomol.

Tillman, P. G. Susceptibility of *Microplitis croceipes* and *Cardiochiles nigriceps* (Hymenoptera: Braconidae), parasitoids of *Heliothis virescens* (Lepidoptera: Noctuidae), to field rates of selected cotton insecticides. For J. Agric. Science.

Tillman, P. G., and L. Lambert. Influence of soybean pubescence on incidence of the corn earworm and the parasitoid, *Microplitis croceipes*. Submitted to Southwest. Entomol.

Tillman, P. G., L. Lambert, and J. Mulrooney. Influence of soybean pubescence on incidence of the beet armyworm and the parasitoid, *Cotesia marginiventris* (Hymenoptera: Braconidae). Submitted to J. Entomol. Science.

Tillman, P. G., and J. L. Roberson. Disposable cardboard box for rearing/release of *Microplitis croceipes*. For Southwest. Entomol.

Weathersbee, A. A., III, D. D. Hardee, and W. R. Meredith. Yield impact of cotton aphid on 12 cotton cultivars differing in leaf tritichome density. Proc. Beltwide Cotton Prod. Res. Conf. (In preparation).

Wood, B. W., J. A. Payne, and M. T. Smith. Foliar sprays of potassium nitrate and surfactant suppress orchard populations of pecan aphids. Horticultural Science. (Submitted to Journal for review).

3. Presentations:

Bell, M. R., and D. D. Hardee. "Tobacco budworm: possible use of various entomopathogens in large area pest management." Proc. Beltwide Cotton Prod. Res. Conf., San Diego, CA, January 1994.

Bell, M. R. "Alternate uses of cottonseed products for insect control." 43rd Oilseed Processing Clinic, New Orleans, LA, March 1994.

Elzen, G. W., S. H. Martin, J. B. Graves, and B. R. Leonard. "Resistance within classes of insecticides in tobacco budworm." Proc. Beltwide Cotton Prod. Res. Conf., San Diego, CA, January 1994.

Elzen, G. W. "Beet armyworm/*Heliothis* research results." Mid-South Cotton Seminar, Rhone-Poulenc, Memphis, TN, January 1994 (Invitation).

Elzen, G. W., S. H. Martin, and J. B. Graves. "Inheritance and reversion of insecticide resistance and current resistance levels in *Heliothis virescens* (F.) in the mid-south USA." World Cotton Conference, Brisbane, Australia, February 1994.

Elzen, G. W., S. H. Martin, J. B. Graves, and B. R. Leonard. "Evaluation of tobacco budworm resistance in 1993." ESA Southeastern Branch Meeting, Baton Rouge, LA, March 1994.

Elzen, G. W. "Mid-South resistance levels." Cotton Consultant Meeting, CIBA, Orange Beach, AL, March 1994 (Invitation).

Elzen, G. W. "Insecticide resistance in cotton insects in the mid-South." Science and Management of Pesticide Resistance, WRCC-60, Las Vegas, NV, April 1994 (Invitation).

Elzen, G. W., S. H. Martin, J. B. Graves, and B. R. Lwonard. "Resistance within classes of insecticides in tobacco budworm-strategies for management." IPM Workshop, Las Vegas, NV, April 1994.

Elzen, G. W. "Insecticide resistance in cotton insects." Decis® Training, Rhone-Poulenc, Greenville, MS, July 1994 (Invitation).

Elzen, G. W. "*Heliothis* responses to conventional insecticides and B.t.'s." Mississippi Insect Control Conf., Mississippi State, MS, November 1994 (Invitation).

Hardee, D. D., A. A. Weathersbee, III, and M. T. Smith. Workshop: "Management of aphids and whiteflies - biological control of the cotton aphid." Beltwide Cotton Prod. Res. Conf., San Diego, CA, January 1994 (Invitation).

Hardee, D. D. "Update on entomology programs with ARS at Stoneville: Sterile moth release, Elcar project, and aphids." 13th Annual Meeting, Mississippi Agr. Consultants Assoc., Greenwood, MS, February 1994 (Invitation).

Hardee, D. D., and M. R. Bell. "Area-wide management of bollworms and budworms with insect pathogens." World Cotton Research Conference, Brisbane, Australia, February 1994.

Hardee, D. D. "Use of novel chemicals in IPM." United Nation's Food and Agriculture and UN Environmental Program Panel of Experts on Integrated Pest Management, Rome, Italy, April 1994 (Invitation).

Hardee, D. D. "Influence of transgenic cotton on numbers of insects, with special emphasis on the tarnished plant bug." Monsanto Briefing on Transgenic Cotton, New Orleans, LA, December 1994 (Invitation).

Hardee, D. D., and J. L. Roberson. "Effect of Dr. Donald Ashdown on boll weevil research." Symposium at ESA National Meeting, Dallas, TX, December 1994 (Invitation).

Hendricks, D. E. "Requisites for dispensing pheromones to disrupt mating behavior of tobacco budworm and bollworm moths in field conditions." S.E. Branch Entomol. Soc. Amer., Baton Rouge, LA, March 1994.

Hendricks, D. E. "Abundance of beet armyworm moths in the cotton-growing region of the lower Mississippi River delta of Mississippi as indicated by captures in pheromone traps from April to November 1994." Mississippi Insect Control Conf., Mississippi State, MS, November 1994.

Scott, W. P. "Temik yield response in narrow row cotton." Rhone Poulenc Cotton Seminar, Memphis, TN, January 1994.

Scott, W. P., D. A. Adams, and R. Shaw. "Effects of row spacings on cotton pest populations and yield." Beltwide Cotton Prod. Res. Conf., San Diego, CA, January 1994.

Scott, W. P., F. E. Cooke, D. Caillvet, and J. C. Walker. "Cost of cotton insect control in Mississippi during 1992." Beltwide Cotton Prod. Res. Conf., San Diego, CA, January 1994.

Scott, W. P. "Insect control and temik use in 30" and 40" cotton." Rhone Poulenc Cotton Production Seminar and Stewardship Meeting, Batesville, Yazoo City, and Greenville, MS, February 1994.

Smith, M. T., S. Galindo, J. R. McVay, and M. J. Hall. "Pecan insect pest management: Recent investigations of the hickory shuckworm sex pheromone." 87th Southeastern Pecan Growers Association Convention, Hilton Head, SC, March 1994.

Smith, M. T., S. Galindo, S., J. R. McVay, and M. J. Hall. "The use of sex pheromone to monitor the hickory shuckworm: An update of current IPM research." Southwestern Pecan Growers Association Convention, Las Cruces, NM, March 1994.

Smith, M. T. "Pecan insect pest management: Recent investigations of alternatives to insecticidal control of the hickory shuckworm, stinkbugs, pecan weevil and pecan aphids." Mississippi/Louisiana Pecan Growers Conference, Baton Rouge, LA, June 1994.

Smith, M. T. "Aphid-host plant interactions in pecan." Second National Pecan Workshop, Wagoner, OK, July 1994.

Snodgrass, G. L. "The tarnished plant bug from a to z." Advanced Insect, Disease, and Weed Workshop sponsored by MCES, Starkville, MS, April 1994 (Invitation).

Snodgrass, G. L. and G. W. Elzen. "Insecticide resistance in a tarnished plant bug population in cotton in the Mississippi Delta." 41st Meeting of the Mississippi Insect Control Conf., Mississippi State, MS, November 1994.

Snodgrass, G. L. "Pyrethroid resistance in a field population of the tarnished plant bug in cotton in the Mississippi Delta." S.E. Branch Entomol. Soc. Amer., Baton Rouge, LA, March 1994.

Snodgrass, G. L. and G. W. Elzen. "Efficacy of Naturalis-L for adults and nymphs of the tarnished plant bug in cotton." Beltwide Cotton Prod. Res. Conf., San Diego, CA, January 1994.

Snodgrass, G. L. "Pyrethroid resistance in a field population of the tarnished plant bug in cotton in the Mississippi Delta." Beltwide Cotton Prod. Res. Conf., San Diego, CA, January 1994.

Tillman, P. G. "Comparison of efficiency of the native normal-winged *Microplitis croceipes* versus a clipped-winged mutant." 41st Meeting of the Mississippi Insect Control Conf., Mississippi State, MS, November 1994.

Weathersbee, A. A., III, and D. D. Hardee. "Aerial dispersal of entomopathogen, *Neozygites fresenii* (Nowakowski) Batko, spores in cotton." S.E. Branch Entomol. Soc. Amer., Baton Rouge, LA, March 1994.

Weathersbee, A. A., III, D. D. Hardee, and W. R. Meredith. "Yield comparison between smooth and hairy isolines of cotton subjected to different levels of aphid infestation." Beltwide Cotton Prod. Res. Conf., San Diego, CA, January 1994.

IV. PLANNED RESEARCH CALENDAR YEAR 1995:

A. *NARRATIVE:*

1. In-House

Plans for 1995 include repeating the 1994 large area test incorporating the application of an entomopathogenic virus on weeds within a large area of crop land in the Mississippi Delta. A 20 mile diameter test conducted in the spring of 1994 demonstrated positive results; however, the efficacy was not completely demonstrated. The test requires the application of virus on an area of at least 314 square miles (201,037 acres) located in the Mississippi Delta near Stoneville. The test area selected has been used for testing and monitored for insect populations by researchers at SIML for the past 9 seasons; therefore considerable background knowledge is available. Although pheromone traps would again be used somewhat, the major evaluation of effectiveness would be based on actual numbers of budworm or bollworm larvae or eggs found in cotton fields within the area during the first seasonal infestation by these pests. The numbers would be compared to those found in the untreated area surrounding the treated area, and fields well away from the treated area. Other additive control measures within the test area, and those measures that may be taken against the first generation of larvae on cotton to further reduce the populations of these pests, may also be considered and tested. **(M. R. Bell, G. L. Snodgrass, D. D. Hardee)**

In order to conduct a large test, we must again produce the virus. The 1994 test provided most of the information needed in order to accomplish this task. A second year will provide additional knowledge of methodology needed to scale up the production if the research results in a large scale IPM program. The final virus formulation will be examined to conform to the label. **(M. R. Bell)**

As time and funding permit, studies on a new baculovirus having a broad host range (celery looper virus) will continue through laboratory bioassays against tobacco budworms, cotton bollworms, and other available insect hosts, as well as continued studies of the new virus having increased effectiveness against beet armyworms. **(M. R. Bell)**

If time permits, additional cage and infection studies will be conducted whereby the early season weed hosts of lepidopterous pests in the Mississippi Delta are treated with various entomopathogens for evaluation of effectiveness in area wide pest management programs. The objective of these studies will be to determine the effectiveness of various pathogens in reducing the emergence of tobacco budworms, cotton bollworms, and other pest species from early season hosts. **(M. R. Bell)**

The Stoneville Research Quarantine Facility (SRQF) will continue to receive in-coming shipments in support of research for the Southern Insect Management Laboratory. Currently the biological control research is on *Bemisia tabaci* and the *Helicoverpa zea* sterile hybrid research project. **(W. W. Bryan)**

We will continue examination of rearing enhancement and conservation methods of *M. croceipes* as a biological control agent for *H. zea* in cotton and soybeans. **(W. W. Bryan)**

Analysis of leaf chemistry of each Juglandaceae species and pecan cultivar will be continued. **(O. T. Chortyk, M. T. Smith)**

We will continue to evaluate the utility of the adult vial test for detecting the frequency of resistance to OP's and carbamates in tobacco budworm. **(G. W. Elzen)**

We will monitor budworm/bollworm populations for tolerance to B.t. **(G. W. Elzen)**

Products for tarnished plant bug control will be evaluated in cooperation with G. Snodgrass to measure resistance in plant bugs. **(G. W. Elzen)**

Evaluations of growth regulators and biologicals will be continued. **(G. W. Elzen)**

Studies with Bt transgenic cotton, MD51, and grower varieties will be repeated to verify insect numbers as affected by the transgenic and nectariless traits. Tests in 1995 will be with the commercial variety of Bt cotton to be released by D&PL Company. **(D. D. Hardee, W. W. Bryan)**

Greenhouse and laboratory studies on effect of aldicarb on cotton aphid resistance to insecticides will be expanded to verify previous conclusions. **(D. D. Hardee, A. A. Weathersbee)**

Various new boll weevil attract-and-kill devices supplied by commercial companies will be evaluated to determine their effectiveness in comparison with commercially available devices and traps. **(D. D. Hardee)**

The Stoneville Insect Rearing Research Support Group will maintain nine insect species in 1995. These are tobacco budworm, bollworm, soybean looper, beet armyworm, velvetbean caterpillar, boll weevil, greater wax moth, *Cardiochiles nigriceps*, and *Cotesia kazak*. Also, assistance will be given individual scientists in maintaining insects needed for their research. Artificial diet will be supplied in 30 ml plastic cups and 3.8 liter multicellular trays. Efforts will continue to develop lidding for a disposal multicellular larval rearing tray. The training in insect rearing techniques and the transfer of technology provided to industry will continue. As always efforts will continue to produce high quality insects at the most economical price possible. The research of approximately 150 scientists within USDA-ARS, private industry, and state universities wll be supported by the work of this group. **(G. G. Hartley)**

The insect distribution programs with the Cotton Foundation and the American Soybean Association will continue in 1995. Both programs are expected to be utilized heavily by researchers throughout the United States. Funds provided by these programs will be used to defray insect rearing expenses of the SIML. The egg, pupal and larval stage of: tobacco budworm, bollworm, soybean looper, beet armyworm, and velvetbean caterpillar will be available. **(G. G. Hartley)**

We will study the sequence of occurrence and the distribution of bollworm, budworm and beet armyworm as indicated by survey traps installed near stands of host plants, including wild geranium, crimson clover, cotton, corn, soybean, and smartweed and correlate population fluctuations with survey trap captures and annual climatic conditions. **(D. E. Hendricks)**

Bioactive materials will be formulated including attractants, disruptants, or attracticides affecting mortality or the behavior of insect pests of cotton and other agronomic or wild host plants to suppress destructive insect populations (beet armyworm, tobacco budworm, bollworm, other Lepidoptera). **(D. E. Hendricks)**

We will develop techniques to optimize methods for detecting insect populations in field conditions, and monitoring their densities and dispersal habits. (In Cooperation with agricultural consultants, insect

population prediction modelers, and specialized equipment designers. **(D. E. Hendricks)**

The population density fluctuation patterns of bollworms, tobacco budworms, and beet armyworms will be studied in an attempt to develop correlations with environmental factors prevailing in typical agronomic conditions in the local Mississippi River Delta region. **(D. E. Hendricks)**

Studies to be initiated to use sound and video observations to determine the behavior of foliar feeding insects which damage soybean. **(L. Lambert)**

Studies will continue to determine if the genetic removal of soybean plant pubescence enhances the resistance levels of soybean genotypes with foliar feeding resistance to all species of foliar feeding insects. **(L. Lambert, T. C. Kilen)**

Studies will be continued to determine the influence of soybean plant maturity on insect resistance. **(L. Lambert)**

Evaluations of the USDA-ARS soybean germplasm collection will continue in an effort to identify resistance soybean damaging insects. **(L. Lambert, T. C. Kilen)**

Studies will be continued with soybean isolines with normal, dense and glabrous pubescence types to determine the influence of pubescence on the effectiveness of parasitoids. **(L. Lambert, P. G. Tillman)**

Studies will be continued with soybean to determine the influence of irrigation of soybean on the development of soybean looper populations and the subsequent impact on yield. **(L. Lambert, L. G. Heatherly)**

The IRRU will maintain colonies of *Anthonomus grandis grandis, Heliothis virescens, Helicoverpa zea, Microplitis croceipes,* and *Spodoptera exigua* for mass-rearing research and production service. Plot preparation, tray assembly materials, and colony insects will be provided upon request to local, federal, and state scientists, and off-site Cotton Foundation recipients for reimbursement of material and processing costs. An active technology transfer policy will be continued with other insect rearing operations (federal, state, and commercial) to incorporate mechanized production processes within their programs. **(J. L. Roberson)**

Major mass rearing programs of the IRRU are as follows: Production of 8 million *Helicoverpa zea* for production of a baculovirus; production of *Spodoptera exigua* larvae for use to propagate and assess virus species for applied field control use; production of *Anthonomus grandis grandis* larvae for production of *Catolaccus grandis*, and production of *Heliothis virescens* to establish and maintain colonies of *Microplitis croceipes* and *Cardiochiles nigriceps*. **(J. L. Roberson)**

A grant was funded through Cotton Incorporated to study tarnished plant bug populations and their effect on yield in nectaried and nectariless cotton varieties. Recommended thresholds of tarnished plant bugs as sampled with the drop cloth, sweep net, and by visual methods will be validated. **(W. P. Scott, G. L. Snodgrass)**

Spray table and small plot studies will continue to evaluate Fipronil and Admire on various cotton pests. **(W. P. Scott, G. L. Snodgrass)**

Spray table studies will be conducted to determine if Buctril herbicide can be mixed with various insecticides without decreasing activity on various cotton pests. **(W. P. Scott, G. L. Snodgrass)**

Analysis of biological and behavioral performance data on all three aphid species on each Juglandaceae species and pecan cultivar will be completed. **(M. T. Smith)**

SEM analysis of the potential role of leaf surface and/or internal morphology in host plant resistance among the Juglandaceae species and the various pecan cultivars will be completed. **(M. T. Smith, Rex Paul)**

Development of an artificial diet bioassay method for evaluation of phytochemicals (natural products) isolated from the various non-preferred or unsuitable Juglandaceae species and/or pecan cultivars will be continued. **(M. T. Smith)**

Investigations to elucidate the mechanism(s) which govern the host specificity of *M. caryella, M. pecanis* and *M. caryaefoliae* among the hickory and walnut species native to the United States, as well as among the pecan cultivars, will be conducted utilizing grafted plants of each Juglandaceae species and pecan cultivars. **(M. T. Smith, C. C. Reilly, B. W. Wood)**

Investigations to determine the utility of a trap cropping system designed to intercept migrating stinkbug species as they move from soybean to pecan in late season will be continued. Based upon the 1993-94 test results, speckle pea will be evaluated for a second season. Sampling methods for stinkbugs will be compared, and a stinkbug control program within the trap crop will be investigated. **(M. T. Smith, G. L. Snodgrass, B. Horton, T. Jenkins, M. Hughs, T. Winters)**

Research designed to re-evaluate the hickory shuckworm (HSW) sex pheromone (formulation and trap density recommendations), and to develop a mating disruptant will be continued. Additional chemical analysis and field bioassays are planned, particularly to include both insect and/or host odors, as well as whole nuts and phylloxera galls. **(M. T. Smith, Ecogen, G. Greis, T. Winters, S. Galindo, C. Yonce, T. Jenkins)**

Research of the pecan weevil pheromone and spatial distribution will continue. Additional volatile collections, and EAD and chemical characterization will be performed, as well as field evaluation of various chemistries (insect and/or host odors) for attractancy to the weevil. The third year of intensive weevil trapping in two orchards should provide very useful information with respect to predictability of weevil density via crop load two years hence. Additional information will be obtained on the efficiency of the 'Tedders trap' as a method for direct control of the pecan weevil. Efforts will also be made to develop a trap design which takes advantage of the weevil's aggregation behavior. **(M. T. Smith, G. Greis, H. Pierce, R. Dearing, F. Taylor)**

Research may be conducted to evaluate several entomopathogenic nematodes for control of the pecan weevil. **(M. T. Smith, R. W. Martin (Biosys), J. Kuhre)**

Insect:plant:parasitoid interactions of the Silverleaf whitefly, *Bemesia argentifolia* will be continued. More specifically, host finding and host selection processes of various parasitoid species of *B. argentifolia* will be investigated in a comparative study of a wide range of its known host plant species. Natural enemy developmental biology, feeding behavior, oviposition and searching behavior will be investigated. **(M. T. Smith, R. Hennessey)**

An evaluation of the efficacy of an aerially applied virus on wild host plants in April to control F_1 bollworm and tobacco budworm larvae on the wild hosts will again be performed (as in 1994) in June and

July in 1995. The same 4 large areas used in 1994 will again be used in 1995. **(G. L. Snodgrass, M. R. Bell, D. D. Hardee)**

Insecticide resistance monitoring will be conducted in 1995 using a glass vial bioassay and plant bugs collected from several locations in the Delta during April and May 1995. Bugs from these same locations will then be tested again in July and August, and results from the 2 time periods compared. This work is part of a Mississippi Cotton Incorporated Grant received for 1995. **(G. L. Snodgrass, W. P. Scott)**

A large field experiment will be conducted using nectaried and nectariless cotton in a commercial field. The experiment is designed to test treatment thresholds and associated sampling methods used to determine them (as recommended by the Mississippi Cooperative Extension Service) to see if they work. The work is part of the grant listed in the preceeding paragraph. **(G. L. Snodgrass, W. P. Scott)**

Cooperative work with Miles Inc. to determine if and for how long cotton plants grown from imidacloprid (Gaucho) treated cotton seed retain enough of the insecticide to control first instar plant bugs will be conducted. The study will be done in the greenhouse during the winter. **(G. L. Snodgrass)**

Cooperative work with Mycogen Inc. on control of plant bugs with BT toxin may occur. **(G. L. Snodgrass)**

A new rearing method at GAST facility with *C. nigriceps* will be tried. **(P. G. Tillman)**

A new rearing method for *C. kazak* to increase female to male sex ratio will be evaluated. **(P. G. Tillman)**

Spray table toxicity tests for *C. marginiventris* will be conducted. **(P. G. Tillman)**

We will continue to study diapause induction and diapause termination for *M. croceipes*. Flightless mutant and normal-winged *M. croceipes* will be compared in a large cage and small field plots. Releases in spring host plants (geranium) will be compared with those made in early summer (cotton). **(P. G. Tillman)**

We will study probable complimentary parasitism between *M. croceipes* (attacks 3rd instars) and *C. kazak* (attacks 1st and 2nd instars). **(P. G. Tillman)**

We will determine if in-furrow insecticides cause the nectar from cotton flowers to be toxic to *M. croceipes* and *C. nigriceps*. **(P. G. Tillman)**

The effect of a sesame nursery in cotton on parasitism by native parasitoids will be studied. **(P. G. Tilman)**

We will determine timing and number of releases of *M. croceipes* for control of *H. zea* in soybeans. **(P. G. Tillman)**

Cotton host-plant resistance research will continue with emphasis on identifying cotton genotypes which tolerate potential yield losses due to cotton aphids. Field plot design for the '95 season will be similar to that used last year, including a cross-section of commercial and experimental cultivars. An evaluation of the mechanisms of resistance will be incorporated into the study. **(A. A. Weathersbee, III, D. D. Hardee)**

Field studies of *N. fresenii* spore dispersal will continue. This work was not conducted during the '94 season because heavy rainfall occurred during the epizootic in cotton aphids. The experiment will be designed to yield quantitative information regarding spore density at different locations within the plant canopy and within the field. **(A. A. Weathersbee III and D. D. Hardee)**

Data will be collected for a third year regarding the dynamics of *N. fresenii* epizootics in cotton aphid populations. These data will be used to examine the predictive ability of a regression equation which will be developed from data collected over the past two years. The equation should be able to predict, with a known degree of probability, the date that aphid populations will begin to decline due to entompathogenic activity. **(A. A. Weathersbee III, D. D. Hardee)**

2. Extramural

If funding is obtained from a submitted proposal, a test will be conducted to evaluate the persistence of baculovirus on various crops as well as early season hosts of the tobacco budworm and cotton bollworm and evaluate the relationship of persistence to the epizootic potential of the pathogen. Such tests would be conducted in cooperation with the University of Arkansas. **(M. R. Bell)**